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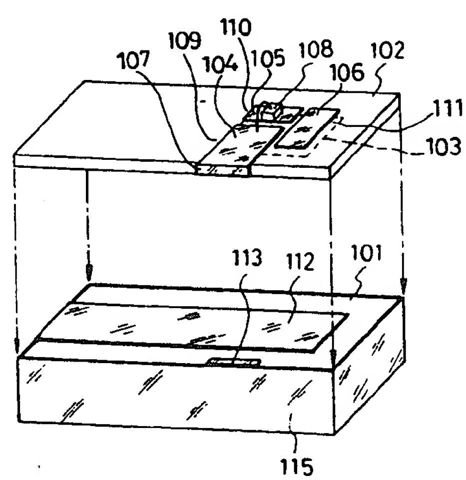
(54) **Frequency tunable resonator including a varactor.**

(57) A coupled capacitor substrate (102, 413, 502, 603) having thereon a plane capacitor (109 = 103 + 104) is integrally bonded on a dielectric resonator (101, 401, 501, 601); and a varactor (108, 408, 508, 608) is mounted on the coupled capacitor substrate so as to couple the dielectric resonator via the plane capacitor (103 + 104).

FIG.1 (a)



EP 0 590 612 A1

FIELD OF THE INVENTION AND RELATED ART STATEMENT

1. FIELD OF THE INVENTION

This invention relates to a frequency tunable resonator including a varactor (variable capacitance diode) which is widely used in an oscillator of frequencies from VHF to EHF bands.

2. DESCRIPTION OF THE RELATED ART

Recently, a resonance circuit combining a dielectric resonator and a varactor is widely used in oscillators for high frequency wireless apparatuses.

A frequency tunable resonator including a varactor is configured by coupling a dielectric resonator and the varactor via a chip capacitor forming a resonance circuit on a circuit substrate.

FIG. 8 shows a configuration of a typical exampl of a conventional frequency tunable resonator including a varactor. As shown in FIG. 8, the conventional resonator comprises a dielectric resonator 81, a varactor 82, a printed substrate 83 and chip capacitors 84, 85 and 86. The dielectric resonator 81 is electrically connected to the varactor 82 via the chip capacitor 84. The chip capacitor 85 is a coupling capacitor for coupling an oscillation circuit, which is provided in an external oscillator (not shown), and the frequency tunable resonator including the varactor. The chip capacitor 86 is connected in parallel with the dielectric resonator 81, thereby lowering a resonance frequency. The conventional resonator further comprises a grounded electrode 87, a voltage control terminal 88 and a connection terminal 89 for the oscillation circuit.

Next, the operation of the conventional frequency tunable resonator including the varactor 82 will be explained with reference to FIG.8. The dielectric resonator 81 is formed by short-circuiting at the end of a coaxial line so as to form quarter-wavelength resonator, and give an infinite impedance at a resonance frequency. The varactor 82 varies its own capacitance depending upon a D.C. applied voltage, and thus can vary an oscillation frequency of the external oscillator by using this capacitance variation. A variation range of an oscillation frequency, which responds to a variation of D.C. applied voltage, can be varied by changing a capacitance of the chip capacitor 84 which connects the diel ctric resonator 81 and the varactor 82. The smaller the capacitance is set, the narrower a variation range of a frequency becomes. On the contrary, th larger th capacitanc is set, the wid r th variation range of the frequ ncy becom s.

The ext rnal oscillator oscillates at a frequency near the resonanc fr quency of the di lectric resonator 81 on the condition that an impedance of the resonance circuit using capacitances of the varactor 82 and the chip capacitor 84 meets an impedance requirement of the oscillation. Since the oscillation frequency generally shifts from the resonance frequency of the dielectric resonator 81 to a slightly lower frequency, the oscillation frequency is adjusted by cutting the length of the dielectric resonator 81 after mounting the dielectric resonator 81 and the chip capacitor 84 on the printed substrate 83.

However, the above-mentioned conventional frequency tunable resonator including the varactor 82 had some problems that miniaturization of them is difficult and that characteristic adjustment is possible only after mounting both parts on the printed substrate 83, because the dielectric resonator 81 and the varactor 82 are connected via a circuit formed on the printed substrate 83.

OBJECT AND SUMMARY OF THE INVENTION

In order to solve the above-mentioned problems, the invention is to provide a frequency tunable resonator including a varactor, which has a miniature size and does not require the characteristic adjustment after mounting parts on a printed substrate.

A frequency tunable resonator including a varactor in accordance with the present invention comprises:

a dielectric resonator;

a coupled capacitor substrate having thereon a plane capacitors and being fixed on the dielectric resonator into an unitary configuration, and

a varactor mounted on the coupled capacitor substrate, in a manner that the dielectric resonator is coupled with the varactor via the plane capacitors.

According to the present invention having the above-mentioned construction, a dielectric resonator and a varactor are connected via a plane capacitor by using the above configuration, and therefore realizes an integration of the dielectric resonator, capacitors and the varactor can be realized, and a frequency tunable resonator which is formed in a miniature size can be obtained. The characteristics adjustment is not required after mounting parts or components on a printed substrate.

While the novel features of the invention are set forth particularly in the appended claims, the invention, both as to organization and content, will be better understood and appreciated, along with oth r objects and f atures ther of, from th following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1(a) is an explod d perspective view showing a frequency tunable resonator including a varactor of a first embodiment of the present invention.

FIG. 1(b) is a plan view showing electrodes of a coupled capacitor substrate of the frequency tunable resonator of FIG. 1(a).

FIG. 1(c) is a side view of the coupled capacitor substrate of FIG. 1(b).

FIG. 1(d) is a rear view of the coupled capacitor substrate of FIG. 1(b).

FIG. 2 is an equivalent circuit diagram of the frequency tunable resonator of the first embodiment of the present invention.

FIG. 3(a) is a plan view showing a coupled capacitor substrate having another structure of the first embodiment of the present invention.

FIG. 3(b) is a side view of the coupled capacitor substrate of FIG. 3(a).

FIG. 3(c) is a rear view of the coupled capacitor substrate of FIG. 3(a).

FIG. 4 is an exploded perspective view showing a frequency tunable resonator including a varactor of a second embodiment of the present invention.

FIG. 5(a) is an exploded perspective view showing a frequency tunable resonator including a varactor of a third embodiment of the present invention.

FIG. 5(b) is a plan view showing a coupled capacitor substrate of the frequency tunable resonator of FIG. 5(a).

FIG. 5(c) is a side view of the coupled capacitor substrate of FIG. 5(b).

FIG. 5(d) is a rear view of the coupled capacitor substrate of FIG. 5(b).

FIG. 6(a) is an exploded perspective view showing a frequency tunable resonator including a varactor of a fourth embodiment of the present invention.

FIG. 6(b) is a plan view showing a coupled capacitor substrate of the frequency tunable resonator of FIG. 6(a).

FIG. 6(c) is a rear view showing the coupled capacitor substrate of FIG. 6(b).

FIG. 6(d) is a plan view showing a printed substrate for connecting external circuit.

FIG. 6(e) is a rear view of the printed substrate of FIG. 6(d).

FIG. 7(a) is a perspective view showing a rear face of the frequ ncy tunable resonator of FIG. 6(a) for showing a first adjusting method.

FIG. 7(b) is a perspective view showing a r ar face of the resonator of FIG. 6(a) for showing a second adjusting method.

FIG. 8 is the perspective view showing a conventional frequency tunable resonator including the varactor.

It will be recognized that some or all of the Figures are schematic representations for purposes of illustration and do not necessarily depict the actual relative sizes or locations of the elements shown.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following paragraphs, a frequency tunable resonator including a varactor of the present invention will be explained in detail on the concerning the preferred embodiments shown in the attached drawings.

((First Embodiment))

FIG. 1(a) is an exploded perspective view showing a frequency tunable resonator including a varactor of the first embodiment of the present invention, FIG. 1(b), FIG. 1(c) and FIG. 1(d) are respectively a plan view, a side view and a rear view showing electrodes of a coupled capacitor substrate of a frequency tunable resonator including a varactor shown in FIG. 1(a).

In FIG. 1(a), the coupled capacitor substrate 102 is mounted on a planar type dielectric resonator 101, and electrodes 103, 104, 105 and 106 are provided on the coupled capacitor substrate 102. Furthermore, a side electrode 107 is provided on a side face of the coupled capacitor substrate 102, and a varactor 108 is fixed on the electrode 105. The planar type dielectric resonator 101 is made by plating and planning a metal, such as Cu (thickness: 6 -- 8 μm) or Ag (thickness: 10 μm), on a ceramic material block, such as barium titanate block.

A plane capacitor 109 is constructed by the electrodes 103 and 104, a plane capacitor 110 is constructed by the electrodes 103 and 105, and a plane capacitor 111 is constructed by the electrodes 103 and 106. The electrode 103 is connected to a strip line resonator electrode 112 of the planar type dielectric resonator 101, and the terminals of the varactor 108 are connected to the electrodes 104 and 105, respectively. In the first embodiment, an anode terminal of the varactor 108 is connected to the electrode 104, and a cathode terminal is connected to the electrode 105. The electrode 104 is connected via the side electrode 107 and a rear electrode 114 provided on the coupled capacitor substrate 102 to an electrode 113 of th planar typ dielectric resonator so as to be grounded. The l ctrode 106 is connected to the oscillation circuit of the external oscillator (not

shown). A reference numeral 115 indicates a grounded electrode.

Next, the operation of the above-mentioned frequency tunable resonator including the varactor 108 will be explained further referring to FIG. 2. FIG. 2 shows an equivalent circuit diagram to the above-mentioned frequency tunable resonator including the varactor 108 of the first embodiment, and corresponding parts to the parts of FIG. 1 are d signated by the same reference numerals. In FIG. 2, reference numeral 201 denotes a voltage control terminal, and reference numeral 202 indicates an oscillation circuit connection terminal.

The planar type dielectric resonator 101 is formed by short-circuiting at the end of a strip line resonator electrode 112 so as to have a length of a quarter-wavelength and has an infinite impedance at a resonance frequency. The varactor 108 varies its capacitance depending upon a D.C. applied voltage and can control an oscillation frequency of the oscillator by utilizing this capacitance variation. The plane capacitor 110 couples the varactor 108 with the planar type dielectric resonator 101, and a range of variation of oscillation frequencies which corresponds to variation of D.C. voltages applied to the varactor 108 can be varied by changing the capacitance of the plane capacitor 110. The plane capacitor 109 is electrically connected to an open end portion of the strip line resonator electrode 112 of the planar type dielectric resonator 101 and a grounded conductor 115, and operates to lower the resonance frequency. The plane capacitor 111 performs capacitive coupling between the planar type dielectric resonator 101 and the external oscillation circuit. That is, the plane capacitors 109, 110, and 111 perform the same function as that of the chip capacitors 86, 84 and 85 of the aforementioned conventional frequency tunable resonator shown in FIG. 8. The electrode 105 of the plane capacitor 110 serves as a voltage control terminal electrode, and the electrode 106 of the plane capacitor 111 serves as a connection terminal electrode for connecting the oscillation circuit.

In the above-mentioned configuration of the first embodiment, the plane capacitors 109, 110, and 111 are formed on the coupled capacitor substrate 102, and thus the frequency tunable resonator of the first embodiment of the invention can be miniaturized as compared with a conventional resonator using the chip capacitors. The rear electrode 103 of the plane capacitors 109, 110, and 111 are directly connected to the electrode 112 formed on the planar type di lectric resonator 101 by mechanical contacts, and th plan capacitors 109 and 110 ar connect d to th varactor 108 dir ctly. Thus the configuration of th first embodiment does not requir a printed circuit on substrat as shown in FIG. 8. And an adv rse ff ct du to an inductance in the wiring patterns of the printed substrate can be eliminated by the configuration of the embodiment.

Furthermore, in the first embodiment, the planar type dielectric resonator 101, plane capacitors 109, 110, 111 and the varactor 108 are integrated into one unit, and hence the characteristics of the frequency tunable resonator including the varactor 108 can be measured by easy handling. Thus, dispersion or scattering of the oscillator's characteristic can be minimized by trimming the frequency tunable resonator including the varactor 108 before mounting it on a substrate having active elements, etc., in the oscillator (not shown). As a result, the productivity is improved. Frequency adjusting of the frequency tunable resonator including the varactor as a whole can be effected not only by trimming the strip line resonator electrode 112 of the dielectric resonator but also by varying the size of the electrodes 104, 105 and 106. Therefore a frequency adjusting range becomes wide and degradation of resonance Q caused by cutting the dielectric resonator can be reduced. In the aforementioned conventional device, it was difficult to control a range of variation of oscillation frequencies which corresponds to variation of D.C. voltages applied to the varactor 108. But, in the first embodiment, it can be easily performed by varying the size of the electrode 105.

In the first embodiment, the electrode 104 is electrically connected to the rear electrode 114 of the coupled capacitor substrate 102 via the side electrode 107. But instead, it may be connected via a plated through hole 301 provided on the coupled capacitor substrate 102 as shown in FIG. 3.

《Second Embodiment》

A second embodiment of the present invention will be explained with reference to the drawings.

FIG. 4 is an exploded perspective view showing a frequency tunable resonator including a varactor of the second embodiment of the present invention. In FIG. 4, the frequency tunable resonator comprises laminate type dielectric resonator block 401, a resonator electrode 402, a shield electrode 403, capacitor electrodes 404, 405 and 406 forming capacitors, a side grounded electrode 407 for connecting the short-circuit side of the resonator electrode 402 to the shield electrode 403 to be grounded, and a varactor 408. A capacitor 409 constructed by the resonator electrode 402 and the capacitor electrode 404, a capacitor 410 constructed by the r sonator el ctrod 402 and the capacitor l ctrode 405, and a capacitor 411 construct d by th resonator lectrode 402 and the capacitor el ctrod 406. The terminals of the varactor 408 are connected to the capacitor electrode

404 and the capacitor electrode 405, respectively. In this second embodiment, an anode terminal of th varactor 408 is conn ct d to the capacitor electrode 404, and a cathode terminal is connected to the capacitor electrode 405. The capacitor electrode 405 is connected to a voltage control terminal 415 and supplied with a control voltage from an external unit. The capacitor electrode 404 is connected via a side-face-grounded electrode 412 to the shield electrode 403 to be grounded; and the capacitor electrode 406 is connected via an oscillation circuit connection electrode 416 to an external oscillation circuit (not shown).

The difference of the second embodiment of FIG. 4 from the first embodiment of FIG. 1 resides in that the whole of the frequency tunable resonator is formed by a laminate structure. The other portions are almost the same.

Next, the operation of the above-mentioned frequency tunable resonator of the second embodiment will be explained with reference to FIG. 4. An equivalent circuit of the frequency tunable resonator including the varactor 408 of the second embodiment is the same as that of FIG. 2, and thus the principle of operation of the circuit is almost the same as the first embodiment. The resonator electrode 402 is short-circuited at the end of strip line of substantially a quarter-wavelength, and the laminated dielectric resonator obtains the maximum impedance at a resonance frequency. The capacitor 410 couples the varactor 408 and the resonator electrode 402. A range of variation of oscillation frequencies which corresponds to variation of D.C. voltages applied to the varactor 408 can be varied by changing the capacitance of the capacitor 410. The capacitor 409 functions to lower a resonance frequency of the frequency tunable resonator of the second embodiment. The capacitor 411 capacitively couples the frequency tunable resonator and the oscillation circuit of an oscillator (not shown).

Since the frequency tunable resonator of the second embodiment is constructed by the laminated structure, a thickness of a dielectric sheet 413 between the resonator electrode 402 and the capacitor electrode 404, 405 or 406 can be made so thin as 20μm. Therefore, the capacitor 409, which lowers a resonance frequency of the frequency tunable resonator, can be made to have a large capacitance, thereby enabling to miniaturize the frequency tunable resonator. Furthermore, since the frequency tunable resonator and the capacitors are integrally formed, number of parts can be reduced.

As m ntioned above, in the s cond embodim nt, th whol of the fr quency tunable resonator can be more miniaturized and thinned by employing th laminat d structur . And the productivity can be improv d by reducing numb r of parts and assembling hours. And further, the frequency tunable resonator of the second embodiment is suited for mass-production, because the fr quency tunable resonator is constructed by the above-mentioned laminated structure.

The frequency tunable resonator of the second embodiment may be so structured that another dielectric sheet is overlapped on the dielectric sheet 413 having electrodes as inner electrodes of the capacitors, and the capacitor electrodes 404 and 405 are extended to an upper face via the side-face-grounded electrode 412 of the lamination type dielectric resonator block 401 and the voltage control terminal electrode 415, and then the varactor 408 is mounted on these extended electrodes.

⟨⟨Third Embodiment⟩⟩

A third embodiment of the present invention will be explained with reference to FIGs. 5(a), 5(b), 5(c) and 5(d). FIG. 5(a) is an exploded perspective view showing a frequency tunable resonator including a varactor of the third embodiment of the present invention, FIG. 5(b) is a plan view showing a coupled capacitor substrate 502. FIG. 5(c) is a side view of the coupled capacitor substrate 502 of FIG. 5(b). FIG. 5(d) is a bottom view of the coupled capacitor substrate 502 of FIG. 5(b).

As shown in FIG. 5(a), the frequency tunable resonator comprises a coaxial type dielectric resonator 501, a coupled capacitor substrate 502, electrodes 503, 504, 505 and 506 which are formed on the coupled capacitor substrate 502, a side electrode 507 which are formed on a side face of the coupled capacitor substrate 502 and a varactor 508. A plane capacitor 509 is constructed by the electrodes 503 and 504, a plane capacitor 510 is constructed by the electrodes 503 and 505, and a plane capacitor 511 is constructed by the electrodes 503 and 506. The electrode 503 is contacted to an inner conductor connection electrode 512 which is formed on an open end face of the coaxial type dielectric resonator 501 as shown in FIG. 5(a). The terminals of the varactor 508 are connected to the electrodes 504 and 505, respectively. In this third embodiment, an anode terminal of the varactor 508 is connected to the electrode 504, and a cathode terminal is connected to the electrode 505. The electrode 504 is connected via the side electrode 507 and a rear electrode 514 formed on the coupled capacitor substrate 502 as shown in FIG. 5(d), to an outer conductor connection electrode 513 to be grounded, and the electrode 506 is connect d to an oscillation (not shown).

A differ nce of the third embodiment of FIGs. 5(a), 5(b), 5(c) and 5(d) from th first mbodim nt of FIG. 1 r sides in that the di lectric resonator is

changed from the planar type dielectric resonator 101 to the coaxial type dielectric resonator 501. The other parts ar almost the same as of FIG. 1.

Next, the operation of the above-mentioned frequency tunable resonator including the varactor of the third embodiment will be explained with reference to FIG. 5(a). The coaxial type dielectric resonator 501 is obtained by short-circuiting at the nd of a coaxial line (transmission line) of substantially a quarter-wavelength, and has an infinite imp dance at a resonance frequency. A resonator having a higher Q value than that of a planar type dielectric resonator can be obtained by using a coaxial dielectric resonator. The varactor 508 varies its own capacitance depending upon a D.C. applied voltage, and thus an oscillation frequency of an oscillator can be adjusted by utilizing this capacitance variation. The plane capacitor 510 couples the varactor 508 and coaxial type dielectric resonator 501, and thus a range of variation of oscillation frequencies which corresponds to variation of D.C. voltages applied to the varactor 508 can be varied by changing the capacitance of the plane capacitor 510. The plane capacitor 509 is connected to an open end of the inner conductor connection electrode 512 of the coaxial type dielectric resonator 501 and a grounded conductor 513 and operates to lower a resonance frequency. The plane capacitor 511 capacitively couples the coaxial type dielectric resonator 501 and the external oscillation circuit. The electrode 505 serves as a voltage control terminal electrode, and the electrode 506 also serves as an oscillation circuit connection terminal electrode.

As mentioned above, this third embodiment can realize a frequency tunable resonator including a varactor which has a high Q value by employing a coaxial type dielectric resonator as the resonator.

In the third embodiment, the electrode 504 is connected to the rear electrode 514 of the coupled capacitor substrate 502 via the side electrode 507; but alternatively it may be connected via a plated through hole.

((Fourth Embodiment))

A fourth embodiment of the present invention will be explained with reference to the drawings.

FIG. 6(a) is an exploded perspective view showing a frequency tunable resonator including a varactor of th fourth embodiment of the present invention. FIG. 6(b) is a plan view showing a coupled capacitor substrate 602, and FIG. 6(c) is a rear view showing th coupl d capacitor substrat 602. FIG. 6(d) is a plan vi w showing a printed substrate 603. FIG. 6(e) is a rear view of the print d substrat 603.

As shown in FIG. 6(a), the frequency tunable resonator of this fourth embodiment comprises a planar type dielectric resonator 601, the coupled capacitor substrate 602, the printed substrate 603 for connecting of an external circuit, electrodes 604, 605, 606 and 607 which are formed on the coupled capacitor substrate 602, and a varactor 608. A plane capacitor 609 is constructed by the electrodes 604 and 605, a plane capacitor 610 is constructed by the electrodes 604 and 606, and a plane capacitor 611 is constructed by the electrodes 604 and 607. Each terminal electrode 612, 613 or 614 having plated through hole is formed on the printed substrate 603 with an electrode pattern 615. A through hole 616 is provided in the printed substrate 603 and sealed with hermetic material 617. A reference numeral 618 denotes a strip line resonator electrode having a recess shape which is formed over a recess-bottom face and recess-side faces of the planar type dielectric resonator 601. The strip line resonator electrode 618 is short-circuit portion to a grounded electrode 619 on a lower face of the planar type dielectric resonator 601. The electrode 604 is contacted to the strip line resonator electrode 618, and the terminals of the varactor 608 are connected to the electrodes 606 and 607, respectively. In this forth embodiment, an anode terminal of the varactor 608 is connected to the electrode 606, and a cathode terminal is connected to the electrode 607. The electrode 605 is connected via a plated through hole to the oscillation circuit connection terminal electrode 612 on the printed substrate 603, and the electrode 606 is connected via the plated through hole to the terminal electrode 613 for grounding, and the electrode 607 is connected via the plated through hole to the voltage control terminal electrode 614. A reference numeral 620 denotes a connecting wire at the varactor 608.

A difference of the fourth embodiment of FIGs. 6(a), 6(b), 6(c), 6(d) and 6(e) from the first embodiment of FIG. 1 resides in that the electrode portion of the planar type dielectric resonator 601 is provided in the recess, in which the coupled capacitor substrate 602 is placed, and furthermore the printed substrate 603 for connecting to a circuit (not shown) is bonded together with the planar type dielectric resonator so as to be formed into an integration. The other parts are almost the same as of FIG. 1.

Next, the operation of the above-mentioned frequency tunable resonator including the varactor of the fourth embodiment will be explained with refer nc to FIG. 6(a). Th planar type di lectric resonator 601 is obtained by short-circuiting at th end of a strip line of substantially a quart r-wav l ngth and realiz s an infinit imp dance at a resonance fr quency. The plane capacitor 611 cou-

ples the varactor 608 and the planar type dielectric resonator 601. Thus a range of variation of oscillation frequencies which corresponds to variation of D.C. voltages applied to the varactor 608 can be varied by changing the capacitance of the plane capacitor 611. The plane capacitor 610 is connected to an open end portion of the strip line resonator electrode 618 of the planar type dielectric resonator 601 and the grounded terminal electrode 613 of the printed substrate 603, and operates to lower a resonance frequency. The plane capacitor 609 capacitively couples the planar type dielectric resonator 601 and the external oscillation circuit.

In the above-mentioned structure of this fourth embodiment, the frequency tunable resonator including the varactor 608 is configured as a module of a unitary body having the terminal electrodes, and therefore this structure facilitates mounting of the resonator on another printed substrate.

In addition, since the electrodes of the plane capacitors and the terminal electrodes on the printed substrate 603 are contacted via the plated through holes formed in the printed substrate 603, these connection between the electrodes and terminal electrodes can be easily effected by inserting solder into the plated through holes of the printed substrate 603.

Furthermore, by forming the through hole 616 in a portion of the printed substrate 603 overlapping the varactor 608, the printed substrate 603 is prevented from contacting with the varactor 608 and the connecting wire 620. And connections between the varactor 608 and the electrodes on the coupled capacitor substrate 602 can be easily checked via the through hole 616. And furthermore, by sealing the through hole 616 with hermetic material 617 such as resin, imperfect contact between the varactor 608 and electrodes can be prevented and durability of the frequency tunable resonator as a module is improved. Besides, before sealing, the electrodes 606 and 607 of the plane capacitors can be contacted directly through the through hole 616, therefore a connection test between the electrodes 606 and 607 and the terminal electrode 613 and 614 can be performed easily. In addition, a resonance frequency or a range of variation of resonance frequencies can be adjusted by cutting the electrode of the plane capacitor. Furthermore, an electrode pattern as shown in FIG. 6(a) can be formed anywhere on the printed substrate 603, and therefore a device such as a high frequency choke coil circuit using a coil electrode pattern, which has be n conv ntionally formed on an external circuit substrate, can be formed on a printed substrat as a modul . Thus miniaturization of th device can be realized.

In addition, the resonator electrode 618 on the planar type dielectric resonator 601 is formed into the r cess-shape strip lin , and a lin width is made wide on the open end portion and narrow on the short-circuit end portion. Therefore, positioning of the planar type dielectric resonator 601 and the coupled capacitor substrate 602 can be performed easily by dropping the coupled capacitor substrate 602 into the recess of the open end portion, and this construction improves the productivity. Furthermore, decrease of electrode width on the short-circuit end portion of the resonator electrode 618 leads to increase of an equivalent line length of the strip line, and hence miniaturization of the planer type dielectric resonator 601. Furthermore, the forming of the resonator electrode 618 both over the upper face and the side face of the planer type dielectric resonator 601 leads to further miniaturization of the dielectric resonator is realized.

In addition, as shown in FIG. 7 which is a rear view of an adjusted frequency tunable resonator including a varactor after assembling, side electrode of the resonator electrode 618 is exposed outward, and therefore, by cutting this portion 701, an equivalent line length of the strip line can be increased so as to lower a resonance frequency, or as shown in FIG. 7(b), by heaping up some solder 702, the equivalent line length can be decreased so as to raise the resonance frequency. As a result, resonant frequency can be adjusted after assembling a module of the frequency tunable resonator including the varactor.

Apart from the above-mentioned embodiments wherein a frequency tunable resonator including a varactor is applied to a high frequency oscillator, a modified embodiment may be such that a frequency tunable resonator including a varactor can be applied to a high frequency filter or the like besides a high frequency oscillator.

Although the present invention has been described in terms of the presently preferred embodiments, it is to be understood that such disclosure is not to be interpreted as limiting. Various alterations and modifications will no doubt become apparent to those skilled in the art to which the present invention pertains, after having read the above disclosure. Accordingly, it is intended that the appended claims be interpreted as covering all alterations and modifications as fall within the true spirit and scope of the invention.

Claims

1. A frequency tunable resonator including a varactor comprising:

   a dielectric resonator;

   a coupl d capacitor substrate having thereon a plane capacitors and being fixed on

said dielectric resonator into an unitary configuration, and

a varactor mounted on said coupled capacitor substrate, in a manner that said dielectric resonator is coupled with said varactor via said plane capacitors.

2. A frequency tunable resonator including a varactor in accordance with claim 1, wherein

said coupled capacitor substrate, said dielectric resonator and an external circuit connection printed substrate are fixed into a unitary configuration, and terminal electrodes formed on said printed substrate are electrically connected to said plane capacitors formed on said coupled capacitor substrate.

3. A frequency tunable resonator including a varactor in accordance with claim 2, wherein

said dielectric resonator is a planar type dielectric resonator which is configured of an end short-circuited strip line of substantially a quarter-wavelength, and an open end portion of said planar type dielectric resonator is connected to a plane capacitor's first electrode formed on a first face of said coupled capacitor substrate,

and on a second face of said coupled capacitor substrate, a second electrode is formed at a part of an area opposing to said plane capacitor's first electrode and is connected to a connection terminal of said printed substrate,

and further on said second face a third electrode is formed at a part of a residual area from forming of said second electrode in a manner opposing to said first electrode and is connected to one end of the varactor and also to a grounding terminal of said printed substrate,

and furthermore on said second face, a fourth electrode is formed in a residual area from forming said second electrode and said third electrode in a manner opposing to said first electrode and is connected to the other end of the varactor and also to a voltage control terminal of said printed substrate.

4. A frequency tunable resonator including a varactor in accordance with claim 3, wherein

at least one of said plane capacitors formed on said coupled capacitor substrate and t rminal electrodes on said printed substrate are conn ct d via plated through holes formed in said print d substrat .

5. A fr qu ncy tunable resonator including a varactor in accordance with claim 3, wh r in

plated through holes are formed in a terminal electrode portion on said printed substrate and solder is ins rted into said plated through holes,

and said planar type dielectric resonator, said coupled capacitor substrate and said printed substrate are bonded together, and said terminal electrodes with said through holes on said printed substrate and the plane capacitors formed on said coupled capacitor substrate are electrically and mechanically connected.

6. A frequency tunable resonator including a varactor in accordance with claim 3, wherein

said varactor is mounted on said coupled capacitor substrate, and a through hole is formed in a portion of said printed substrate which overlaps said varactor, thereby to prevent said varactor from contacting with said printed substrate, and said through hole is sealed with resin or the like.

7. A frequency tunable resonator including a varactor in accordance with claim 3, wherein

said printed substrate has at least one of through hole formed in a portion which overlaps a part of electrode patterns of said plane capacitors formed on said coupled capacitor substrate, so as to enable said electrode pattern to connect to an external terminal.

8. A frequency tunable resonator including a varactor in accordance with claim 3, wherein

a coil electrode pattern is formed on said printed substrate, so as to provide a high frequency choke circuit.

9. A frequency tunable resonator including a varactor in accordance with claim 3, wherein

said coupled capacitor substrate is dropped into said planar type dielectric resonator formed with a recess-shape strip line, thereby to be fitted in said planar type dielectric resonator.

10. A frequency tunable resonator including a varactor in accordance with claim 3, wherein

a width of said planar type dielectric resonator formed in a recess-shape strip line is made wide on said open end portion and narrow on a short-circuit end portion, and said coupled capacitor substrate is dropped into the wid portion of said recess-shape strip line, ther by to b fitt d in said planar type di lectric r sonator.

11. A frequency tunable resonator including a varactor in accordance with claim 3, wherein
said end short-circuited strip line of substantially a quarter-wavelength is formed with a recess which covers two faces of an upper face and a side face on a short-circuit end side of said planar type dielectric resonator.

12. A frequency tunable resonator including a varactor according to claim 3, wherein
said end short-circuited strip line of substantially a quarter-wavelength is formed with a recess which covers two faces of an upper face and a side face on a short-circuit end side of said planar type dielectric resonator, and a resonance frequency is adjusted by cutting an electrode of said side face on the short-circuit end side.

13. A frequency tunable resonator including a varactor in accordance with claim 3, wherein
said end short-circuited strip line of substantially a quarter-wavelength is formed with a recess which covers two faces of an upper face and a side face on a short-circuit end side of said planar type dielectric resonator, and a resonance frequency is adjusted by heaping up some solder on the electrode of said side face on the short-circuit end side.

14. A frequency tunable resonator including a varactor comprising:
a planar type dielectric resonator configured of an end short-circuited strip line of substantially a quarter-wavelength;
a first electrode which is formed on a first face of a coupled capacitor substrate connected to an open end side of said planar type dielectric resonator; and
a second electrode, which is formed on a second face of said coupled capacitor substrate opposing to the first electrode, and connected to one end of the varactor, thereby to couple said planar type dielectric resonator with said varactor via a plane capacitor having said first electrode and said second electrode.

15. A frequency tunable resonator including a varactor in accordance with claim 14, wherein
a grounded electrode is formed on said second face of said coupled capacitor substrate and connected to a resonator grounded electrode of said planar type dielectric resonator via a sid lectrod of said coupled capacitor substrate, and th other terminal of said varactor is conn cted to said grounded electrod on said s cond face so as to be grounded.

16. A frequency tunable resonator including a varactor in accordance with claim 14, wherein
a grounded electrode is formed on said second face of said coupled capacitor substrate and connected to a resonator grounded electrode of said planar type dielectric resonator via a plated through hole formed in said coupled capacitor substrate, and the other terminal of said varactor is connected to said grounded electrode on said second face so as to be grounded.

17. A frequency tunable resonator including a varactor in accordance with claim 14, wherein
on said second face of said coupled capacitor substrate, a third electrode is provided in a residual area from forming said second electrode opposing to said first electrode, and is used as an external connection terminal.

18. A frequency tunable resonator including a varactor in accordance with claim 14, wherein
on said second face of said coupled capacitor substrate, a third electrode is provided in a part of a residual area from forming said second electrode opposing to said first electrode, and is used as an external connection terminal,
and furthermore on said second face, a fourth electrode is formed in a residual area from forming said second electrode and said third electrode opposing to said first electrode and is connected to the other terminal of said varactor and is grounded via a side electrode of said coupled capacitor substrate.

19. A frequency tunable resonator including a varactor in accordance with claim 14, wherein
on said second face of said coupled capacitor substrate, a third electrode is formed in a part of a residual area from forming said second electrode opposing to said first electrode, and is used as an external connection terminal,
and furthermore on said second face, a fourth electrode is formed in a residual area from forming said second electrode and said third electrode opposing to said first electrode and is connected to the other terminal of said varactor and is grounded via a plated through hole formed in said coupled capacitor substrate.

20. A frequency tunable resonator including a varactor comprising:
a planar type di lectric resonator configur d of an end short-circuited strip line electrode of substantially a quarter-wavelength;

a capacitor electrode, which is provided on a thin dielectric layer of a laminate structure, and which forms a capacitor b tween itself and said end short-circuited strip line electrode of said planar type dielectric resonator, and which connects to one terminal of a varactor so as to couple said planar type dielectric resonator with said varactor via said capacitor electrode.

21. A frequency tunable resonator including a varactor in accordance with claim 20 further comprising:
a connection electrode, which is formed on the same layer on which said capacitor electrode of said dielectric layer is provided, and connected to the other terminal of said varactor and grounded via said grounded electrode.

22. A frequency tunable resonator including a varactor in accordance with claim 20 further comprising:
a second capacitor electrode is formed on the same layer on which said capacitor electrode of said dielectric layer is provided,
and a second capacitor is formed between said second capacitor electrode and said open end portion of said resonator electrode of said planar type dielectric resonator, and connects to a side terminal electrode so as to be used as an external connection terminal.

23. A frequency tunable resonator including a varactor in accordance with claim 20 further comprising:
a second capacitor electrode which is formed on the same layer on which said capacitor electrode of said dielectric layer is provided,
and a second capacitor is formed between said second capacitor electrode and said open end portion of said resonator electrode of said planar type dielectric resonator, and connects to a first side terminal electrode so as to be used as an external connection terminal,
and furthermore a third capacitor electrode is formed on the same layer on which said first capacitor electrode of said dielectric layer is provided,
and a third capacitor is formed between said third capacitor electrode and said open end portion of said resonator electrode of said planar type dielectric resonator, and connects to the other terminal of said varactor, and said third capacitor lectrode is grounded via a second side grounded electrode.

24. A frequency tunabl resonator including a varactor comprising:
a coaxial type dielectric resonator configured of an end short-circuited transmission line of substantially a quarter-wavel ngth,
an inner conductor connection electrode, which is provided on an open end portion of said coaxial type dielectric resonator, and which is connected to the inner conductor,
a first electrode which is formed on a first face of a coupled capacitor substrate, and which is connected to said inner conductor connection electrode, and
a second electrode which is formed on a second face of said coupled capacitor substrate opposing to said first electrode and connected to one terminal of a varactor so as to couple said coaxial dielectric resonator with said varactor via a plane capacitor having said first electrode and said second electrode.

25. A frequency tunable resonator including a varactor in accordance with the claim 24 further comprising:
an outer conductor connection electrode which is connected to an outer conductor, and which is formed on an open end face of said coaxial dielectric resonator, and
a grounded electrode which is formed on said second face of said coupled capacitor substrate and connected to said outer conductor connection electrode via a side electrode of said coupled capacitor substrate, and the other terminal of said varactor is connected to said grounded electrode so as to be grounded.

26. A frequency tunable resonator including a varactor in accordance with the claim 24 further comprising:
an outer conductor connection electrode which is connected to an outer conductor, and which is formed on an open end face of said coaxial dielectric resonator, and
a grounded electrode, which is formed on the second face of said coupled capacitor substrate, and which is connected to said outer conductor connection electrode via a plated through hole formed in said coupled capacitor substrate, and the other terminal of said varactor is connected to said grounded electrode so as to be grounded.

27. A frequency tunable resonator including a varactor in accordance with the claim 24 further comprising:
on said s cond face of said coupled capacitor substrat , a third electrod which is form d in a r sidual ar a from forming said second lectrod opposing to said first lectrode, and which is us d as an ext rnal con-

nection terminal.

28. A frequency tunabl resonator including a varactor in accordance with the claim 24 further comprising:

on said second face of said coupled capacitor substrate, a third electrode which is formed in a part of a residual area from forming said second electrode opposing to said first electrode, and which is used as an external connection terminal, and

a fourth electrode which is formed in a residual area from forming said second electrode and said third electrode opposing to said first electrode, and which is connected to the other terminal of said varactor so as to be grounded.

FIG.1 (a)

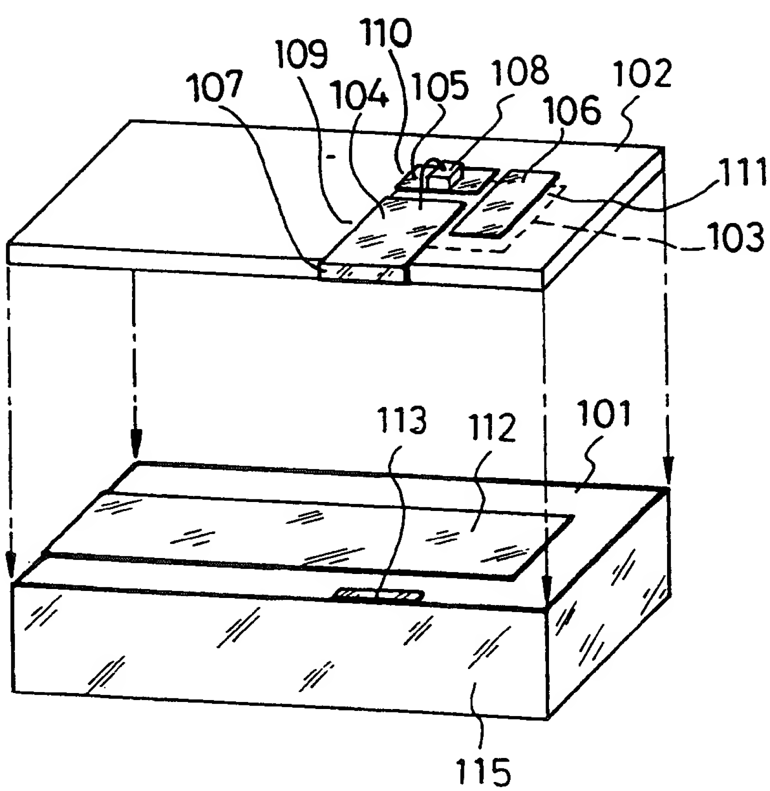


FIG.1 (b)

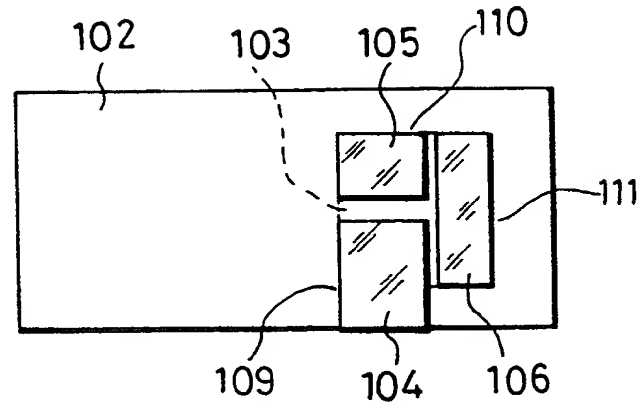


FIG.1 (c)

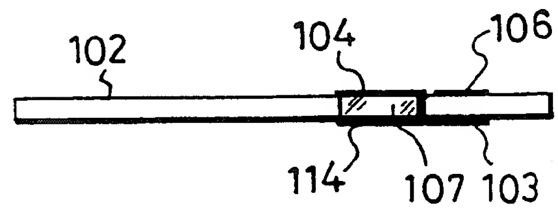


FIG.1 (d)

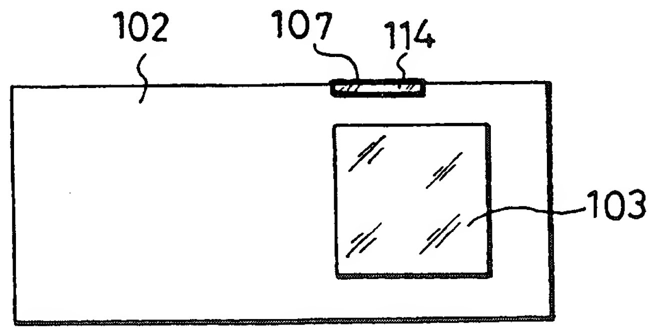


FIG. 2

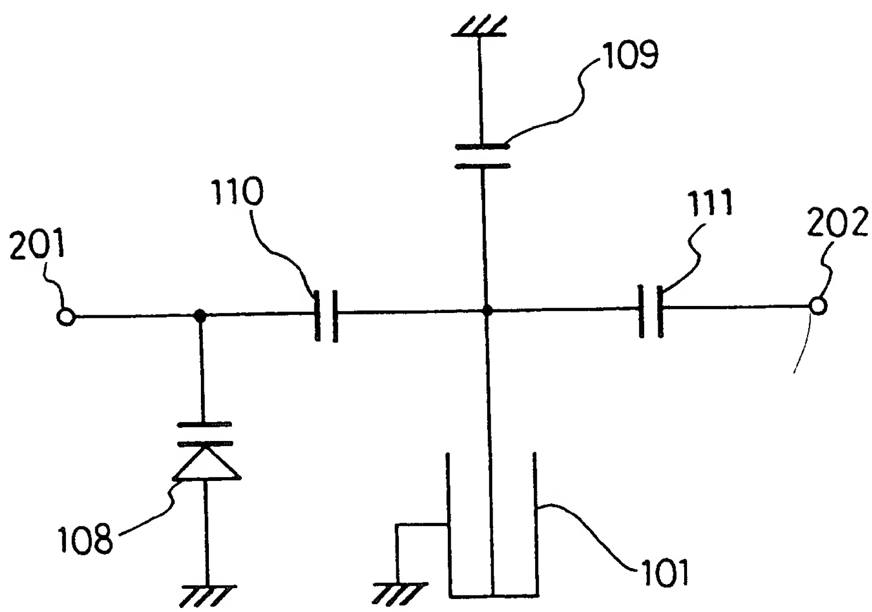


FIG.3 (a)

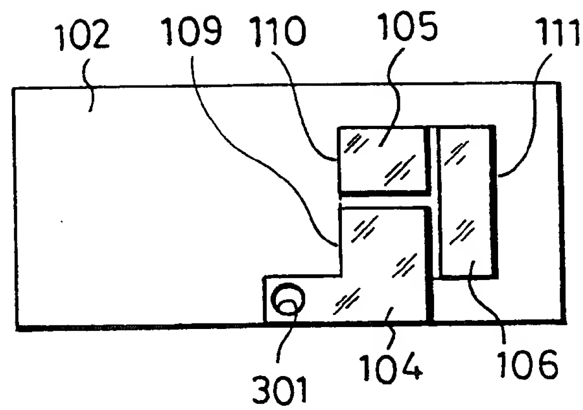


FIG.3 (b)

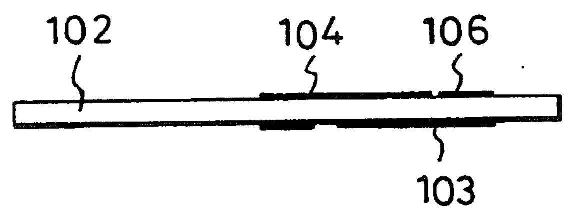


FIG.3 (c)

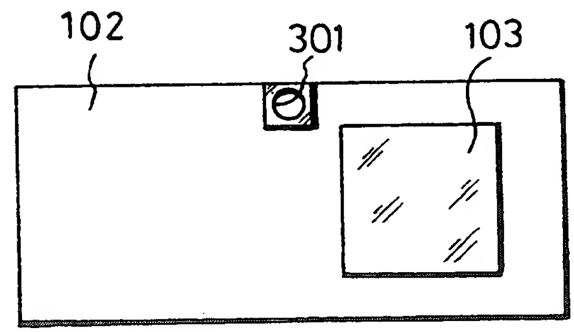


FIG.4

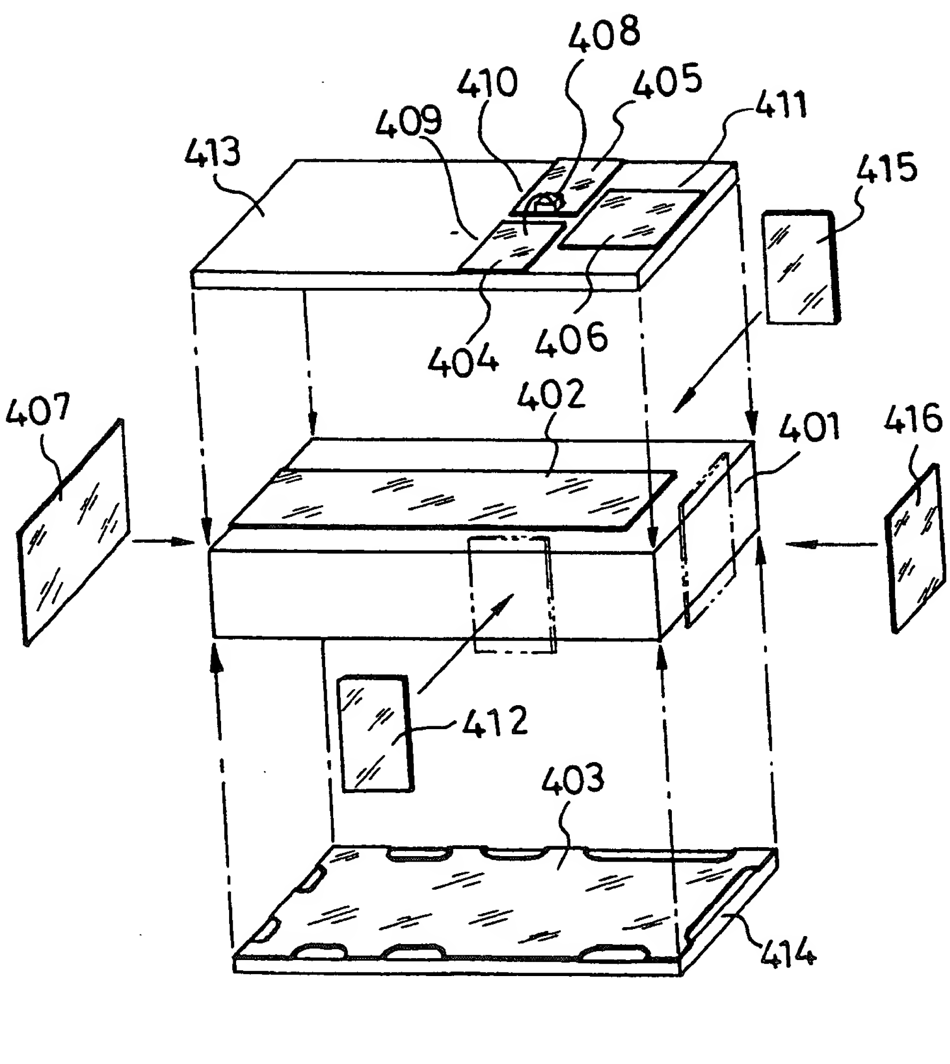


FIG.5 (a)

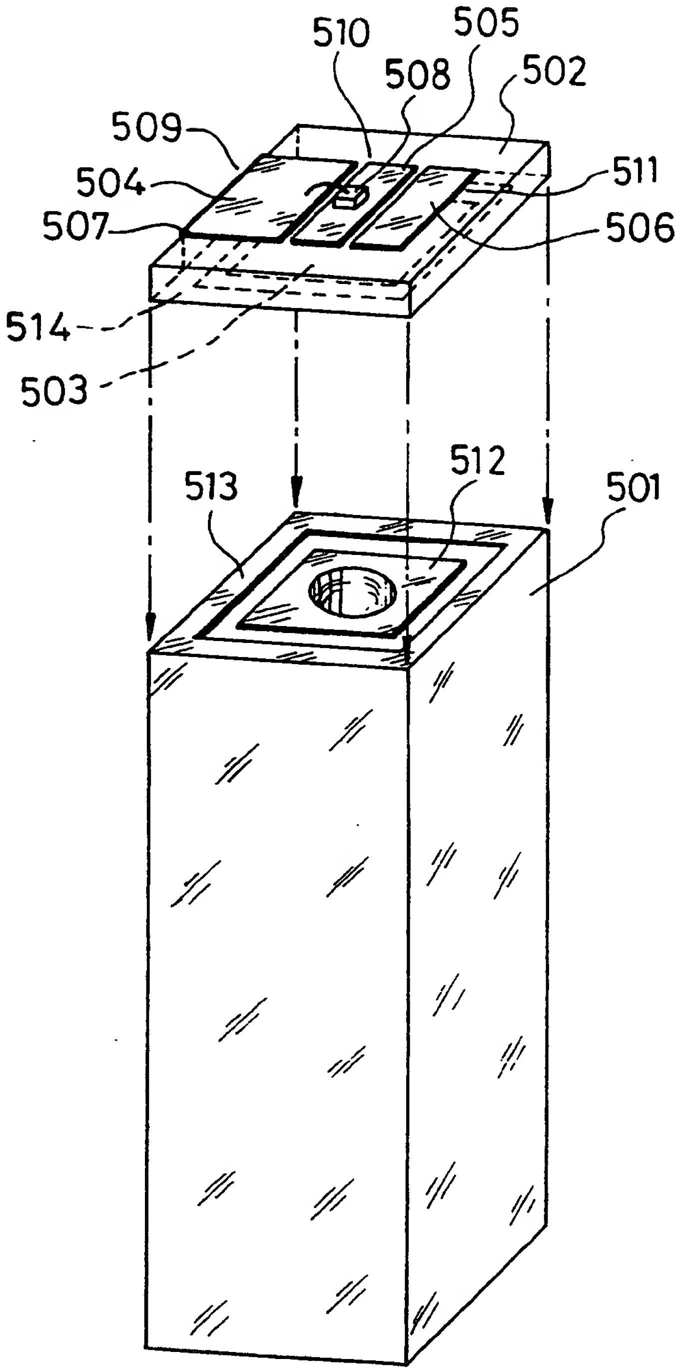


FIG.5(c)

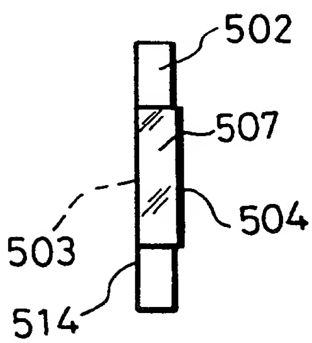


FIG.5(b)

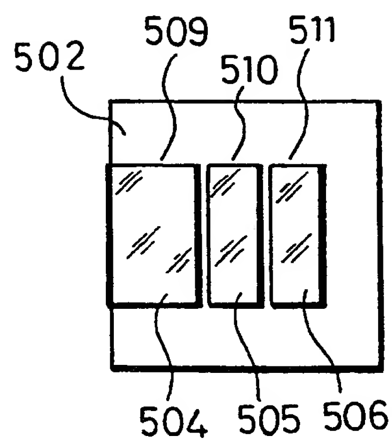


FIG.5(d)

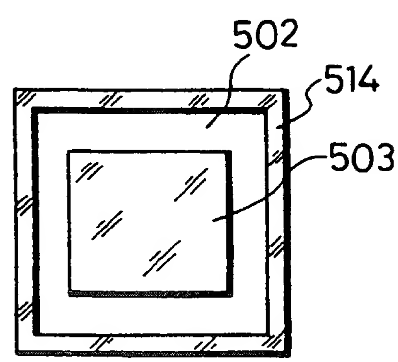


FIG.6 (a)

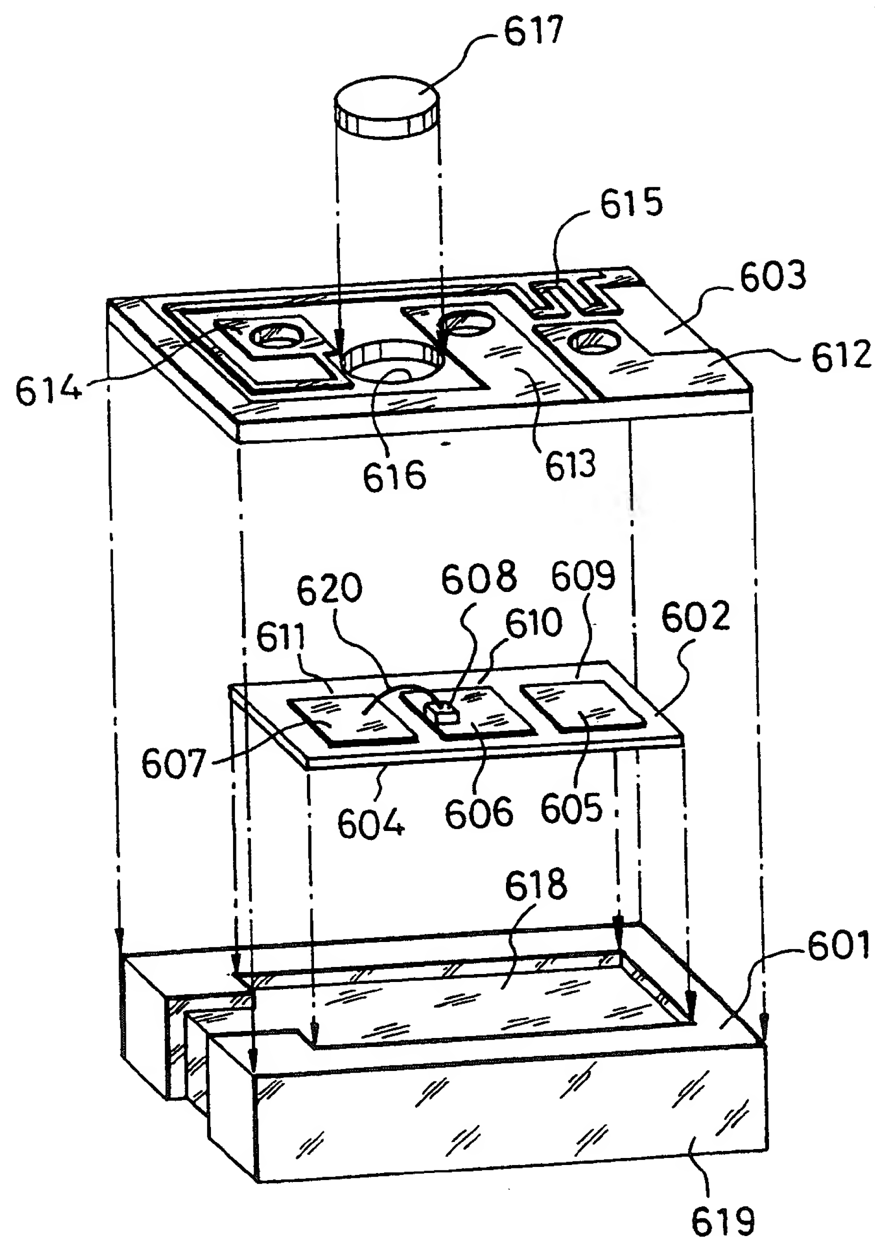

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FIG.6 (b)

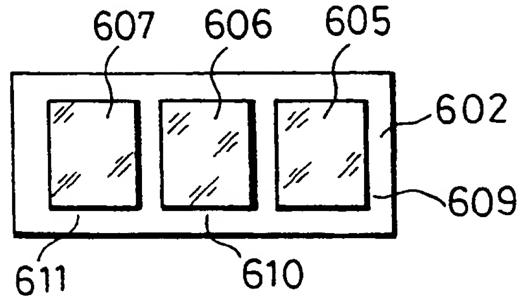


FIG.6 (c)

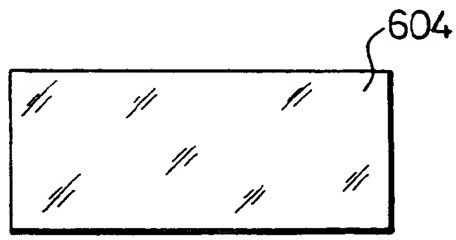


FIG.6 (d)

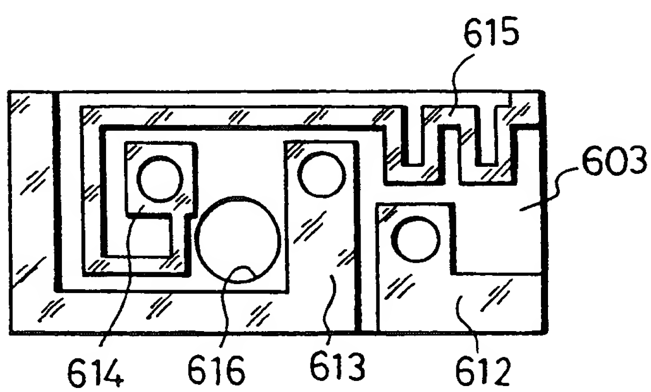


FIG.6 (e)

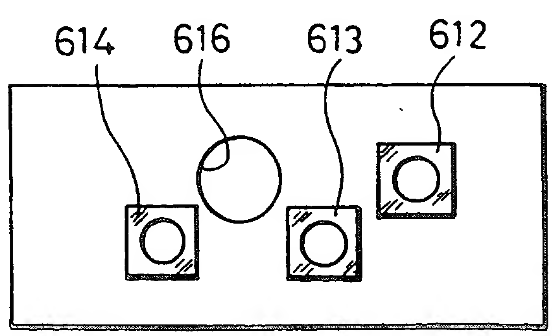


FIG.7(a)

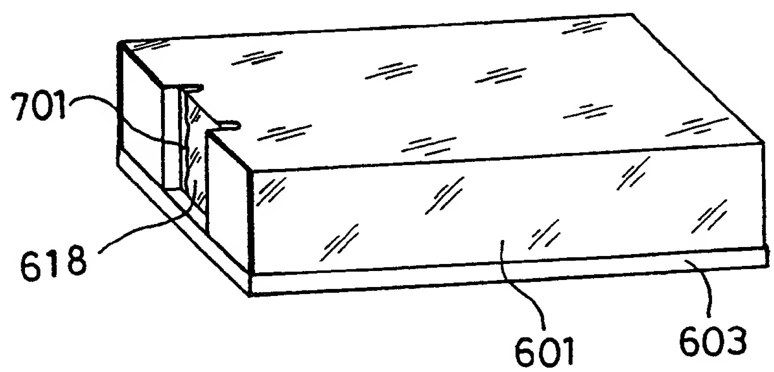


FIG.7(b)

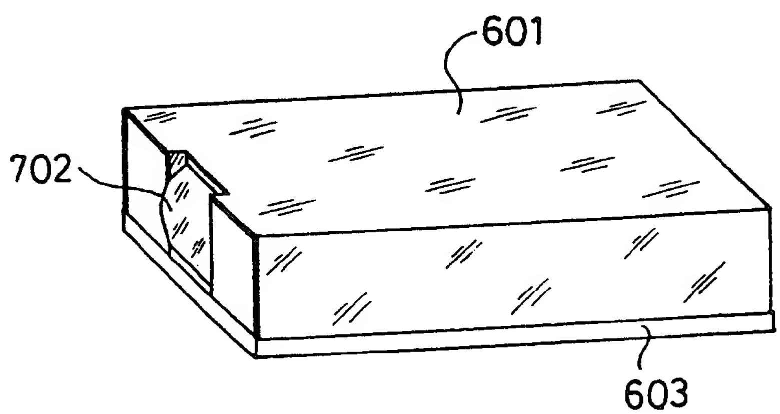
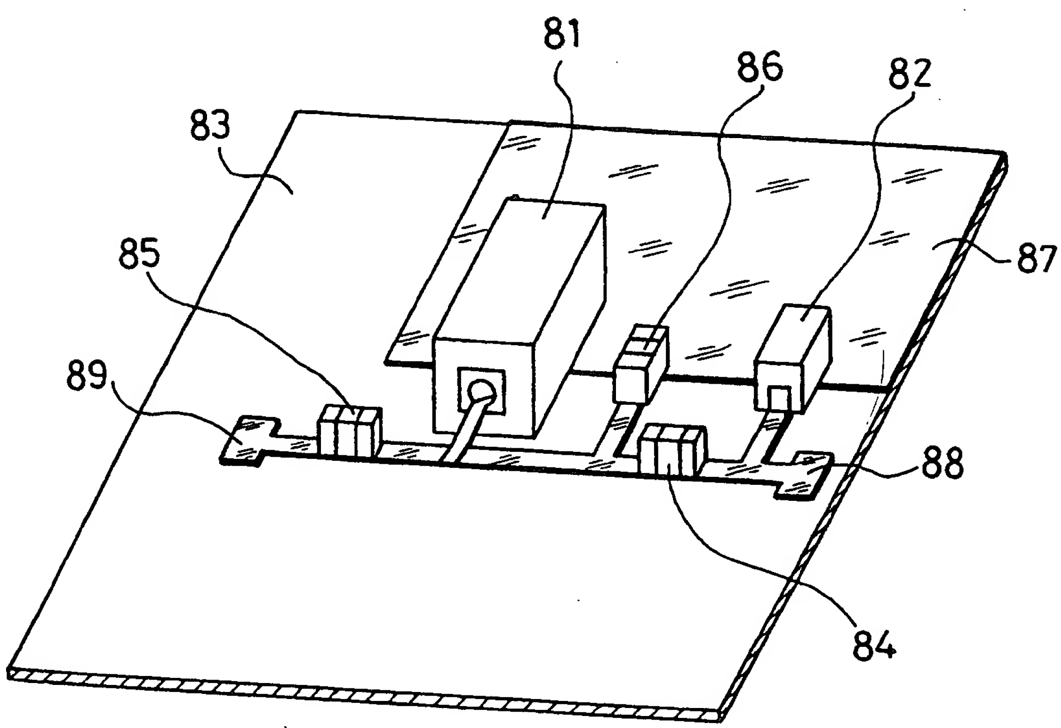


FIG.8 (Prior Art)



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 11 5651

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	US-A-4 721 932 (WEST) * column 2, line 42 - column 3, line 14; figure 1 *	1,2,14, 20,24	H01P7/04 H01P7/08
A	EP-A-0 444 948 (FUJISU LTD.) * column 6, line 51 - column 7, line 2; figures 11,12 *	1,2,14, 20,24	
A	US-A-5 097 237 (KOMAZAKI ET AL.) * column 5, line 46 - column 6, line 2; figure 5 *	14,20	
A	EP-A-0 069 431 (CISE) * page 4, line 27 - page 7, line 28; figure 1 *	1,14,20, 24	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			H01P H03B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	5 January 1994	Den Otter, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
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& : member of the same patent family, corresponding document